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ABSTRACT

This paper presents the results of two studies which were performed to assess the effects of the practice of an interactive video game on spatial visualization test scores. The first study used 70 Laval University undergraduate students as subjects, while subjects for the second study were 101 seventh grade students from the area of Quebec City. In both studies, all subjects were given a pretest and a posttest on the Space Relations Test of the Differential Aptitude Tests (French Canadian version). The experimental groups--one in each study--had eight sessions of playing the interactive video game Zaxxon; the control groups received no such treatment. In the adults' experiment, the 2 (group) by 2 (sex) analysis of covariance yielded a significant effect for group, no effect for sex, and no interaction of group X sex, indicating that both men and women gained significantly and equally from playing Zaxxon. The adolescents' experiment revealed no significant result, and a re-examination of the procedure revealed several problems that may have contributed to these experimental inconsistencies. It is recommended that future studies in the area of training cognitive skills incorporate a more extended practice period, multiple training conditions, and be established on data assuring convergent validity between the game itself and the skills to be trained. A four-page reference list is provided. (Author/DJR)

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Effect of Playing a Video Game on Adults' and Adolescents' Spatial Visualization

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Abstract

This paper presents the results of two studies executed in order to assess the effects of the practice of a video game on spatial visualization test scores. The first study was conducted among adults subjects, whereas the second was realized among adolescents. In both studies, all subjects were given a pretest and a posttest on the Space Relations Test of the DAT. The experimental groups (one in each study) had eight sessions of playing the video game Zaxxon; the control groups received no such treatment. In the adults' experiment, the 2 (group) by 2 (sex) analysis of covariance yielded a significant effect for group, no effect for sex and no interaction of group X sex. This shows that both men and women gained equally and significantly from playing Zaxxon. These results are mainly discussed in terms of the properties of video games which can affect visuo-spatial performance. The adolescents' experiment revealed no significant result. The procedure is therefore re-examine in order to identify problems which may have contributed to the experimental inconsistencies.

Purpose

Since their arrival, video games have become the object of much social polemic. While certain groups are firmly opposed to these games, insisting on stricter legislation with respect to their access and content, others assert that they favor the development of positive attitudes towards computers (Selnow, 1984; Turkle, 1984) and/or that they permit the development of certain cognitive skills (Ball, 1978; Greenfield, 1984, Loftus & Loftus, 1983; Lowery & Knirk, 1982). Moreover, the controversy regarding the positive or negative impacts related to the use of video games has always taken place in public circles where, often, the conclusions convey nothing more than opinions.

Amongst the numerous hypotheses forwarded with respect to the effects of video game use, one of these suggests that visual-spatial skills and more particularly that spatial visualization may be developed by this use. This surfaces on a few occasions in available literature (Greenfield, 1984; Loftus & Loftus, 1983; Lowery & Knirk, 1982). However, before its acceptance, this hypothesis must undergo the necessary experimental testing. This is the object of the present study.

Background

In a first-class review on related literature, McGee (1979) described spatial visualization as the ability to mentally rotate, manipulate, and twist two- and three-dimensional stimulus objects. Further, the superiority of boys over girls in visual-spatial skills shows up frequently in the related literature (Anastasi, 1958; Buffery & Gray, 1972; Garai & Scheinfeld, 1968; Maccoby & Jackin, 1974); on the other hand, certain authors (Burnstein,

Bank & Jarvik, 1980; Harris, 1980; McGee, 1979; Sherman, 1978) conclude that the majority of the research in this area is equivocal.

There have been few attempts to improve the performance on spatial tests by practice or relevant trainings (Blade & Watson, 1955; Brinkman, 1966; Connor, Schackman & Serbin, 1978; Connor, Serbin & Schackman, 1977; Johnson, 1976; Smith & Schroeder, 1979; Stericker & Le Vesconte, 1982; Vanderberg, 1975). Moreover, certain studies yield a significantly better improvement in the scores of the female subjects as compared to those of the male subjects (Connor et al., 1978; Connor et al., 1977; Vanderberg, 1975). Such results suggest that environmental factors can be responsible, at least in part, for the differences established between sexes in visual-spatial skills (Sherman, 1978). However, it should be pointed out that an increase in scores on spatial tests through training does not invalidate conclusions about the genetic components which might influence such test scores (Vanderberg, 1975).

The examination of video games presently available on the market reveals that several have characteristics making them excellent learning tools, notably with respect to visual-spatial skills. The first of these characteristics concerns the motivational aspects inherent in this play activity; furthermore, the literature which treats this subject is abundant (Anderson, 1983; Bowman, 1982; Chaffin, 1983; Chaffin, Maxwell & Thompson, 1983; Malone, 1980; Malone, 1983; Pépin & Leroux, 1984). For the purpose of this paper, we can say that the advantages of "video game assisted training" can, at the motivational level, prove to be particularly appropriate with individuals having few experiences or little success in any particular field (Driskell & Dwyer, 1984).

Secondly, video games are interactive. These interactive qualities are

not only important on the motivational level, but also the area of transfer of learning (Greenfield, 1984).

Thirdly, tridimensionality being a fundamental constituent of spatial visualization, any training used to develop this skill must be, at least in part, also tridimensional (Lowery & Knirk, 1983). In fact certain video games, like Zaxxon, simulate very effectively tridimensionality.

Finally, video games are very fast. This characteristic prevents the player from using verbal-analytical strategies for problem solving.

Considering the positive results reported by the studies relative to the training of visual-spatial skills, and the inherent properties of video games, the following hypotheses are thus formulated:

1. Spatial visualization test scores will be improved by video game playing.

2. Both male and female subjects will improve their scores, but women and girls will improve to a greater extent than men and boys, thus eliminating any sex-related differences that may occur during pre-testing.

To test these two hypotheses, two different studies were executed: the first conducted using adult subjects, and the second using adolescents.

First experiment

Seventy French Canadian undergraduate students, 33 women and 37 men, without prior experience with video games, were selected. Their average age was 22 years, and they were all recruited from the Literature and Humanities

Departments at Laval University. Subjects were randomly assigned to the experimental group (19 men and 19 women) and to the control group (18 men and 14 women)[1].

All subjects were pretested and then posttested six weeks later using the French Canadian version of the Space Relations Test of the DAT (Bennet, Seashore, Wesman & Chevrier, 1960). Forms A and B of the test were administered respectively on both occasions.

Subjects in the trained group were each given eight sessions to play the video game, each session including five games of Zaxxon (Coleco). The frequency of the sessions was determined at the subject's convenience; however, at least one session per week, and no more than two per week was required.

The game Zaxxon was retained because it is one of the few video games presently available on the market which effectivly simulates tridimensionality. Also, spatial visualization as measured by the Space Relations Test of the DAT, requires the mental manipulation of tridimensional objects. In a recent multidimensional scaling of ten video games, Zaxxon positioned itself in the upper extremity of the dimensionality continuum (Bodko, Bobko & Davis, 1984). Lastly, Zaxxon offers excellent qualities ranging from its design to its manipulation (Trudel, 1983). These qualities are indispensable in assuring that the subject's interest level is maintained throughout the game sessions.

Results

Means and standard deviations by sex and groups for pretest and posttest are presented in Table 1.

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[1] Attrition account for the different "ns".

Insert Table 1 here

Group means for the experimental and control subjects both as a whole and for each sex, do not differ significantly at the pretest level. Moreover, significant sex-related differences in visual-spatial skills, frequently reported in the literature, do not appear here on the pretest, although the men tend to exhibit slightly higher scoring.

To assess the effects of sex, group and their interaction on the DAT scores, a 2 (sex) by 2 (group) analysis of covariance was carried out using pretest scores as the covariate; the regression approach used to deal with unequal ns per cell. This analysis yielded a significant group effect on the posttest scores ($F = 6.57$, $p < .05$), no effect from sex, and no interaction from group x sex. This shows that both men and women gained equally and significantly from playing Zaxxon.

These results demonstrate that spatial visualization, such as measured by the Space Relations Test of the DAT, can be improved following the practice of Zaxxon. Nevertheless, these results must be interpreted with some precaution.

It is possible that along with improving the subjects' spatial visualization, the manipulation of three dimensional objects required in Zaxxon may have contributed to an increase in the subjects' motivation when faced with this type of task. Indeed, some authors have suggested that the failure of many individuals facing certain tasks can be attributed mostly to fear of this failure rather than a lacking in the required skills (Stericker & LeVesconte, 1982). The design of most video games, including Zaxxon, constantly reinforces the subject. As a result, even those showing a poor

performance from the start may improve rapidly if they persist in their efforts. It is therefore plausible - and the verbal reports from many subjects confirm this - that the practice of Zaxxon could permit a favorable modification in the subjects' attitude towards visual-spatial tasks. Consequently, they no longer perceive their previous difficulties as being caused by their "incompetence", but simply as the result of a lack of practice and/or an insufficient effort.

The fact that the present study did not yield sex related differences in spatial visualization indicates incertitude that sex related differences in visual-spatial skills actually exist. Finally, the fact that significant improvement was achieved by adults after only eight sessions, led us to expect that the playing of Zaxxon might also result in similar improvements among the younger subjects. Therefore, to respond to this dilemna, a second imquiry was realized.

Second experiment

The subjects of this study were selected following a survey dealing with, among other things, the attitude of youth towards computers and on their "video game habits" (frequency, type of game, location...). This survey was executed in grade seven classrooms at four schools in the Quebec City region. In order to assure the participation of a significant number of subjects, the criteria for selection "having played less than 25 times" was determined a posteriori. One hundred and one subjects, 60 girls and 41 boys, were then to participate in the experiment. The number of girls having seldom played video games coincides with what is frequently reported in the literature: girls are generally less interested than boys in this activity. The average age was 13 years. The subjects were distributed at random in the experimental

group (34 girls and 22 boys) and in the control group (26 girls and 19 boys).

In order to conform to time and space limits imposed by the schools, our method had to be modified, particularly when it came to the game sessions. Hence, each session had to be limited to a 25 minutes period instead of having five games of unlimited duration as in the first experiment. Further, the ensemble of the experimental process had to be completed in the space of three weeks with three out of five game sessions per week for each subject in the experimental group.

Finally, as was the case in the first study, Zaxxon was used for the training sessions and the Space Relations Test of the DAT as measurement of spatial visualization.

Results

Means and standard deviations by sex and groups for pre- and posttest, including gain scores are presented in Table 2.

Insert Table 2 here

One can notice initially that the experimental and the control groups differ significantly at the pretest level ($t = -2.16$, $p < .05$). It also may be pointed out that this difference is particularly noticable with the boys ($t = 2.48$, $p < .05$).

However, there is no significant difference between sexes, and this on both occasions.

Further, the analysis of covariance reveals no significant result. We must therefore conclude that the playing of Zaxxon did not produce the anticipated result.

Nevertheless, the examination of the gain scores underlines two interesting tendencies. First of all, one notices that in spite of a tangible difference (more than eight points at pretest) between the experimental and control groups the former does improve by six points whereas this improvement is only two points for the control group. This tendency is even more marked with the girls, where the experimental group gains more than seven points as compared to less than one point for the control group.

Although, none of our hypothesis were statistically confirmed by our second inquiry, it remains difficult to take a firm position concerning the effects of video game practice on spatial visualization. A re-examination of the procedure revealed three problems which may have contributed to these experimental inconsistencies. Firstly, the imbalance of the groups from the start certainly played an important part. In fact, it is theoretically and empirically admissable that there is more difficulty in improving the scores of the stronger subjects than those of the weaker subjects. Secondly, unlike the adults in the first study, very few adolescents had never played video games, although all subjects reported having played less than twenty-five times before the beginning of the experiment. Finally, in spite of the fact that the number of game sessions was the same (eight) in both studies, the 25 minutes sessions were, generally speaking, shorter than the those fixed with 5 games and no time limit.

Conclusion

We believe our project was ambitious in view of our attempt to enhance performance on a spatial test after only eight sessions of playing a video game. Nevertheless, our partial success in this venture is encouraging. Future studies in the area of cognitive skills training using video games

should incorporate a more extended practice period, multiple training conditions, and be established on data assuring convergent validity between the game itself and the skills to be trained. Regarding these considerations, micro-computer games hold an advantage over arcade type video games, the former being programmable by the researcher.

This, in turn, would allow the game's task requirements to be varied or modified so as to reach an acceptable level of convergent validity with the skills to be trained and, consequently, become more efficient.

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TABLE 1

MEANS AND STANDARD DEVIATIONS BY SEX AND GROUP

DAT	Women			Men			All	
Test	Exp.	Con.	All	Exp.	Con.	All	Exp.	Con.
Pretest								
M	61.4	56.9	59.5	65.0	60.9	63.0	63.2	59.1
SD	15.5	15.3	15.3	19.6	20.4	19.8	17.5	18.2
Posttest								
M	71.7	60.1	66.8	73.2	67.6	70.5	72.4	64.3
SD	9.8	14.7	13.3	18.5	19.7	19.0	14.6	17.9
n	19	14	33	19	18	37	38	32

TABLE 2

MEANS, STANDARD DEVIATIONS AND GAIN SCORES BY SEX AND GROUP

	Girls			Boys			All	
	Exp.	Con.	All	Exp.	Con.	All	Exp.	Con.
Pretest								
M	48.00	43.27	45.95	54.18	40.42	47.80	50.43	42.07
SD	20.74	19.98	20.38	18.06	17.31	18.82	19.79	18.75
Posttest								
M	55.12	44.15	50.37	58.18	43.89	51.56	56.32	44.04
SD	21.25	22.36	22.24	20.43	24.89	23.45	20.80	20.79
Gain Scores								
M	7.12	0.88	4.42	3.47	4.00	3.76	5.89	1.98
SD	12.53	13.53	13.23	13.26	11.38	12.13	12.08	13.32
n	34	26	60	22	19	41	56	45